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Face Identification Attendance System using Gabor Wavelet Method

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Abstract

Most of the existing attendance systems use the current web-based application, fingerprint, card or a special tool as an identification tool. Systems with object identification have some shortcoming. The implementation of the face recognition method using Gabor wavelet (Gabor filter) in the attendance system can identify faces quickly in large number of faces and minimizes attendance fraud. The test shows that the best result is 97% correct recognition with direct direction, a camera located in front of the participant. Whereas the recommended distance between the camera and the face is 30cm with 92% of correct recognition. Lastly, the light intensity variations between 10-710 Lux percentages obtained 99% correct recognition.

Keywords: Face recognition, identification, Gabor Wavelet, Gabor filter, attendance system

INTRODUCTION

Today's security system uses face, retina, and fingerprint recognition. An attendance system is one of the security systems and most of the existing attendance systems use web-based application, fingerprint, and card or a special tool as identification. Unlikely, the systems have significant drawback such as abuse and long queue.

The face recognition has been developed for various purposes, attendance checking for example. This project on the Gabor Wavelet study in face recognition could identify faces quickly in large amount of faces. The attendance system based on face identification using Gabor Wavelet method face recognition can eliminate the drawback in the existing attendance system

LITERATURE REVIEW

Face Recognition in Digital Image Processing

Image processing is a form of processing an image by processing the numerical values of the image, *i.e.* processing each pixel or point of the image. Identification or face recognition is one of the sciences in computer vision, where the computer is able to perform analysis of an image of a face in a picture and discover the identity of the face images in comparison to the face image data that have been stored previously in its database [1]. Generally, facial image recognition is done from direct direction; the camera is located in front of the participants with the lighting conditions spreading evenly throughout the face. But in some cases, the face recognition process may have some specific issues such as position, scale or distance, orientation, age, and expression.

According to Li and Anil (2005) [1], facial image recognition system or face recognition generally includes four main sections modules, namely: detection, alignment, feature extraction and matching. Ideal face detection should be able to identify and find the location and size of all existing face within an image regardless of pose, scale, orientation, age and expression.

Alignment process aims to obtain a more accurate value and a better level of normalization of the face image with face detection which provides estimations of the location and scale of each detected face image. The next process after normalization is extraction which retrieves effective data from a face image and separates it from the data or images that is not required. While the matching process is comparing the data that has been extracted with the face image data stored in the database.

Gabor Wavelet

1) Convolution

Convolution is a mathematical operation on two functions *f* and *h*, producing a third function that is usually seen as a modified version of one of the original function, providing overlapping area between two functions as a function of the amount of one of the original function being translated. Convolution is similar to cross-correlation. It has applications that include probability, statistic, computer vision, image and signal processing, electrical engineering, and differential equation [2].

Total multiplication convolution of two functions *f* and *h* can be defined by the following formula:

$$f * h = \int_0^T f(t)h(T-t)dt \qquad (1)$$

Image filter can be done by using a spatial convolution of the image (*I*) and the filter function (*h*), and written by the following formula:

$$I'(x,y) = \sum_{i=-n}^{n} \sum_{j=-m}^{m} h(i,j)I(x+i, y+j) \qquad (2)$$

where *m* and *n* is the size of the filter function in the matrices.

2) Viola-Jones

Viola-Jones object detection framework is the first object detection framework that provides competitive object detection rates in real-time, proposed in 2001 by Paul Viola and Michael Jones [3].

Although widely applied for the detection of various objects, framework or algorithm has a primary motivation for face detection or face recognition and the algorithm is implemented by OpenCV [4, 5, 6, and 7].

Detection process which detects whether there is a face in an image with OpenCV face detector, an approach to detect objects in the image combines four main concepts (Figure 1 in [3]), namely:

a. Simple rectangular features called Haar features.
b. Integral images for fast feature detection.
c. AdaBoost machine learning methods.
d. Multiple classifiers to connect a lot of features efficiently.

Features used by Viola and Jones are based on the Haar wavelet which is a single square wave (one interval high and one interval low).The features can be described well with one light and one dark for two dimensions.

3) Gabor Filter

It is a linear filter that is used for edge detection. Frequency and orientation representations of Gabor filters are similar to the human visual system that is appropriate for texture representation and discrimination. It is also being used for texture analysis [7, 10], recognition of the low resolution gray-scale characters [8, 11], face detection [9], iris detection, fingerprint detection, and so on.

Object recognition method can be defined as the process of determining the identification of the object based on an existing image in database. In this research, the approach used Gabor wavelet algorithm. The purpose using Gabor wavelet is to raise a special feature of the image that has been convoluted by the kernel. As the filter, it is used Gabor wavelet 2D kernel obtained by modulating a 2D sine wave at a certain frequency and orientation with Gaussian envelope.

If all Gabor filters with frequency variations *(f)* and orientation *(ϑ)* applied to a certain point *(x, y)*, then it can obtain a lot of response filter to the point, for example: using four frequencies *(f=3, 5, 7, 10)* and eight orientations *(ϑ)*, it will produce 32 response filters for each image point that being convoluted with these filters. The image in the database and the image that will be recognized will be convoluted first by using Gabor Filter. The convolution will results points to a specific value called *Gabor jet response*.

Gabor jet response points of the existing image in database and the image that will be recognized then compared by applying graph matching procedure on the image to be recognized. It is by maximizing the similarity between the magnitude of Gabor and the graph model of transformed face with graph representation of the image to be recognized. The application of graph matching can be defined by the following equation:

$$S(J,J') = \frac{\sum_j a_j a'_j}{\sqrt{\sum_j a_j^2 \sum_j a_j'^2}} \qquad (3)$$

Where *J* is the *Gabor jet models* of the image database and *J'* is the Gabor jet models of the image to be recognized. Similarity function *S(J, J')* is defined by the equation above, where a_j and a'_j respectively are points of Gabor jet response of image in database and image to be recognized.

SYSTEM DESIGN

The system has to capture an image and looks for face of the attendant's image. The rest of the phases are image processing and it ends with the similarity calculation from the data base. As for simplified diagram of the design of face recognition system is shown in Figure 1.

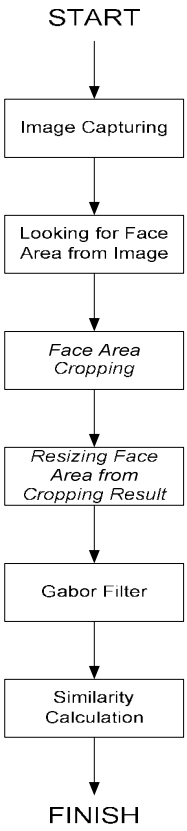

Figure 1: The design of face recognition system

a. Image Capturing

The initial phase that will be carried out by the program is taking pictures/images using the integrated webcam on the computer. It still uses the internal webcam with a size of 640x480 pixels. This size was chosen so that the process of testing a face search program can proceed faster since the resolution being used is not too big.

b. Looking for Face Area from Image

OpenCV is an open source computer vision library, which facilitates programming face detection, face tracking, face recognition, Kalman filtering, and a variety of artificial intelligent methods. The OpenCV uses a face detector type called Haar Cascade classifier [12]. Face detector successfully working on an image. If there is an image, face detector test classifies each image location as the "face" or "not the face".

c. Face Area Cropping

Once the face area is found containing the webcam image capture results, the next step is to crop the facial area only. It aims to save computing time in the process to the next stage. In OpenCV there is a function called cvSetImageROI which is used to crop the desired area. Region of Interest (ROI) in OpenCV is a rectangular area in an image, to divide an object based on the desired segment for further processing.

d. Resizing Face Area from Cropping Result

Once the face area is obtained and stored in *.JPG. Next step is to change the size of the cropped image to be the same size as the other cropped images. At the time of cropping the face area will

produce different sizes of pictures because of the proximity of objects to the camera is not always permanent. Resize aims to get the same size as the facial image databases to facilitate the process of recognition. These images will be resized to 100x100 pixels in size.

e. Gabor Filter

Object recognition method can be defined as the process of determining the identification of the object based on an existing image in database. In this research, the approach used Gabor wavelet algorithm. The purpose of using Gabor wavelet is to raise a special feature of the image that has been convoluted by the kernel. As the filter, it uses Gabor wavelet 2D kernel obtained by modulating a 2D sine wave at a certain frequency and orientation with Gaussian envelope.

f. Similarity Calculation

At this step, it will look for the value of the similarity of the image that will be used as input for the program. The input will be used to identify the image based on features that are known. The convolution will result points to a specific value called Gabor jet response. Gabor jet response points of the existing image in database and the image that will be recognized then compared by applying graph matching procedure on the image to be recognized. It is done by maximizing the similarity between the magnitude of Gabor and the graph model of transformed face with graph representation of the image to be recognized.

TESTING AND ANALYSIS

a. Testing Face Poses

The percentage of success with face recognition for frontal position with a total observation time of 120 observations of 12 students (Figure 2) with each student as much as 10 times. It obtained a total of 117 correct and 3 incorrect facial recognitions. The percentage of success is 97% correct recognitions and recognition failure in the process as much as 3%.

Figure 2: Frontal position observation result

The success range for face recognition with non-frontal position with a total of 12 observations of 120 students is 10 times for each student. Total of correct facial recognition are 92 times and incorrect facial recognition are 28 times. The percentage of success is 77% of correct recognition and failure percentage in the process as much as 23%.

Frontal pose or face positions perpendicular to the camera position is likely to have the same pattern or texture between the face images. When the shooting was done for the input database with the frontal position there is no rotation or shift angle face image which led high correctness of

recognition, the same thing happens in the result of Barbu [9]. However, the position of non-frontal angle tends to result with low correctness of recognition.

b. Distance Testing and Light Intensity

The success rate of face recognition with a variable range of ± 30 cm gave a very good result; the percentage of correct recognition value is very high around 92% while the fail recognition is quite low at 8%. A test was conducted on 12 students (Figure 3) and each student was observed 10 times.

Figure 3: Observation result with ± 30cm distance

The success rate of face recognition with variable distance > 30 cm, as shown in Figure 4, gave unsatisfied results, the percentage of correct recognition value that is 86% while the fail ones are quite low at 14%. Tests conducted with 12 students and each student was observed 10 times.

Figure 4: Observation result with ± 30cm distance

Actually, the effect of student distance to the camera can be overcome with the facial image resizing process; the error is caused due to the recognition of the light intensity at a distance of> 30 cm lower than the range of ± 30 cm so that the resulting texture is not the same pattern for the same individual. In the test using variable light intensity from different observations obtained recognition success rate of 99%, failure rate of 1%. This experiment showed for light variable that has a range of values between 10-710 lumens, a value which suggests a high recognition rate.

Table 1: Observation result for light intensity

No	Voltage (Volt)	Light Intensity (Lux)	Recognition		Similarity (%)
			Right	Wrong	
1	80	10	10	0	83.438
2	100	15	10	0	84.963
3	120	70	10	0	85.429
4	140	110	10	0	85.611
5	160	180	10	0	81.158
6	180	270	9	1	80.005
7	200	370	10	0	77.373
8	220	710	10	0	77.079
		Total recognition	79	1	Total= 81.882

Bright light intensity will produce a different image quality with those having a less bright light intensity. After convoluted by Gabor filter, the intensity of the image of light and dark will produce different pattern features from the same face image. Different feature textures will produce a different matrix composition too. Matrix pattern differences between two images with different intensities will produce recognition results that are not the same. The more similar matrix structure of the image with the image in database will give higher percentage of correct recognition.

CONCLUSION AND RECOMMENDATION

In this paper, the face identification attendance system using Gabor Wavelet method is presented. From the observation during the design phase, implementation and testing process of the system shows that the best test results of 97% correct recognition when the camera is located in front of the participant's face. Whereas, the recommended distance between the camera and the face is 30cm because this distance has the best test results of 92% correct recognition. Testing results shows that the light intensity variations between 10-710 Lux has the highest percentages of 99% correct recognition.
In a case of any abuses, testing by using participants' photo prints obtained percentage of correct recognition of only 9%. The low recognition percentage will be able to prevent an abuse. The higher the percentage of correct recognition on face recognition program, the better the quality of attendance applications based on face identification.

As the variation of camera and algorithm used is not in within this research scope, the repeated project could be conducted using different specifications of the cameras or applying different algorithms such as Eigen face, Neural Network or multilevel wavelet decomposition as the future works. It is recommended to use high specification computer so the processes can perform even fast.

The main contribution of the paper is to show the simplicity and low cost of the system. A student laptop with a webcam can be used in this project and the testing obtained reasonable and reliable percentage recognition.

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References

Li, Stan Z. & Anil K. J. (2005). *Handbook of face recognition*, New York: Springer.

Damelin, Steven B. & William Miller, Jr. (2011). *The mathematics of signal processing, series: Cambridge texts in applied mathematics (No. 48)*, Cambridge: Cambridge University Press.

Viola, Paul & Michael J. Jones. (2001). Rapid object detection using a boosted cascade of simple features. *IEEE Computer Vision and Pattern Recognition.*

Zhu, Qiang, et al. (2006). Fast human detection using a cascade of histograms of oriented gradients. *IEEE Computer Vision and Pattern Recognition, 2,* 1491-1498.

Santana, M. Castrillón, et al. (2008). Face and facial feature detection evaluation: Performance evaluation of public domain haar detectors for face and facial feature detection. *Vision Theory and Application (VISAPP), 2*, 167-172.

Butko, N.J. & Javier R. Movellan. (2009). Optimal Scanning for Faster Object Detection. *IEEE Computer Vision and Pattern Recognition*, 2751-2758.

Rajni Rani and Kamaljeet Kaur, Implementation for Gabor Filter Using on Satellite Images Enhance the Image Quality, International Journal of Advanced Research in Computer Science and Software Engineering (Volume 3, Issue 5), May 2013

Hu, Peifeng, et al. (2002). Recognition of gray character using gabor filters. *IEEE Proceedings of the Fifth International Conference : Information Fusion,1,* 419-424.

Barbu, Tudor, Gabor Filter (2010). Based face recognition technique. *Proceedings of the Romanian Academy, Series A, 11*, 277-283

F. Galasso, J. Lasenby, "Fourier analysis and Gabor filtering for texture analysis and local reconstruction of general shapes," CVPR, pp.2342-2349, 2009 IEEE Conference on Computer Vision and Pattern Recognition, 2009.

Yoshimura, H., et al. (2000). Gray-scale character recognition by Gabor jets projection. *IEEE Proceedings 15th International Conference: Pattern Recognition, 2*, 335-338.

OpenCV Development Team, Cascade Classification http://docs.opencv.org/modules/objdetect/doc /cascade_classification.html (accessed on June, 6th 2013).

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